Climate Change: Need for New Economic Thought

As climate change has moved onto the political agenda, so have economists entered the debate prominently. Addressing the greenhouse effect challenges the approach to resource allocation of mainstream economics. A range of subjects arise: the objectivity of scientific information, asymmetry of costs and benefits over space and time, differentiation between risk and uncertainty, institutional power over information and the role of ethical judgment in decision processes.

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India is the fifth largest emitter of carbon dioxide but lacks a credible policy to address human induced climate change. Reluctance to take action is understandable in a country where per capita emissions are still a fraction of those in the US or Europe. However, in about 30 years, at present growth rates, India's emissions will reach European per capita levels. At the Ninth Biennial Conference of the International Society for Ecological Economics (New Delhi, December 15-18, 2006) the point was repeatedly and forcefully made that India is neither offering self-restraint nor claiming a "carbon debt" by asking for reductions in other countries' emissions. Besides activity in the market for "clean development mechanism" projects, which will have little impact on emissions trends, India is practically silent on the international stage. India appears to be in denial over global aspects of human induced climate change, focusing if anything on internal concerns such as changing patterns of the monsoon.

This article explores the development of human induced climate change as an international policy concern and the reasons why no country can sit on the sidelines. Natural science has been at the forefront of the debate, with climatologists leading due to their role in the Intergovernmental Panel on Climate Change (IPCC) and its four Assessment Reports (AR).[1] However, as regulation of various emissions has moved onto the political agenda so economists and others have entered the debate more prominently.

As will be seen, seriously addressing the enhanced greenhouse effect challenges the approach to resource allocation of mainstream economics. A range of subjects arise including: the objectivity of scientific information, asymmetry of costs and benefits over space and time; differentiation between risk and uncertainty; institutional power over information and policy; and the role of ethical judgment in decision processes. Each is a major topic requiring research and posing serious challenges to the current conceptualisation of pollution as a technical problem, which requires an engineered optimal solution. Similar problems have been and continue to be posed by other pollution "externalities". The difference in the case of the enhanced greenhouse effect is how the issues confront the analyst simultaneously, are non-separable and arise on a global scale.

Impacts of Global Climate Change

The greenhouse effect is one of the better understood features of the atmosphere; the science having been established in the 1800s by the likes of Arrhenius, Fourier and Tyndall. Arrhenius (1896) estimated that a doubling of CO_2 would cause 4.9-6.1ºC increase in continental surface air temperature depending upon latitude and season, which is at the upper end of current predictions (1.4ºC-5.8ºC under the Third AR).[2] While detailed understanding has improved, the basic science from over a century ago remains unchanged, along with many of Arrhenius' predicted relationships. The greater controversy surrounds exactly how human induced climatic change will be realised at the regional level and across time, who will suffer and what should be done.

Overall the variability in climate and precipitation predicted from simulation models at the regional level is far greater than that at the global scale. In their review for the Second AR, Kattenberg et al (1996: 344) concluded: "Considering all models, at the 10^4-10^6 km^2 scale, temperature changes due to CO_2 doubling varied between +0.6ºC and +7ºC and precipitation changes varied between –35 per cent and +50 per cent of control run values, with a marked inter-regional variability". The potential regional effects combine numerous positive and negative impacts. Global warming would alter precipitation patterns, evapotranspiration, and the length of growing seasons, affecting food supplies, changing crop and forest growing regions, raising sea level, spreading disease and pests, and reducing the number of animal species.

The benefits and costs of human induced climatic change will be unevenly distributed between nations [d'Arge et al 1982; Broadus et al 1986; Kosobud and Daly 1987; Glantz 1990; d'Arge and Spash 1991]. Even given imprecise projections, the general direction of change can be estimated, and regions and populations at risk identified. Africa is the most vulnerable continent because of widespread poverty limiting adaptation capabilities [Watson et al 1997: 6]. Some groups are particularly vulnerable such as those living in shanty towns established in flood-prone areas and on unstable hillsides; or low-income rural population dependent upon traditional agriculture and marginal lands in tropical Asia, where the 1,600 million population is principally rural based [Watson et al 1997: 11, 15-16]. An increase in the rate of sea level rise, storm surges and precipitation can clearly be identified as threatening populations and capital in low lying areas both in developing (e g, Egypt, Bangladesh, India) and developed economies (including cities such as London). Wealthier nations with better endowments of fertile soils, less arid land, further inland and/or above sea level will be tempted to ignore less fortunate regions. Population migration will undoubtedly occur as land is lost to rising seas and storm surges, and agricultural productivity is reduced in semi-arid regions.

Economists need to be concerned with how climate change will affect the welfare of different economies, nations and groups.

Even beneficial agricultural impacts, due to CO_2 fertilisation, would change the comparative advantage of producing nations and so affect world trade. Imposing negative changes on industrially developing countries raises ethical concerns for redistribution and compensation [d'Arge and Spash 1991]. If, say, the outcome of global climate change was that the industrially developed north was made better-off by more than the industrially developing south was made worse-off, no actual compensation is required under "the potential compensation test", as applied in modern welfare economics, because on aggregate the world is a better place. Such ethical concerns are an integral part of the issue but are generally ignored or quickly dismissed [e g, Stern 2006: 42]. That this flies in the face of liability law, let alone moral responsibility, seems of no consequence to economists who often hide their moral judgments in technical detail.

The intertemporal asymmetry of impacts is also apparent as initial benefits to some regions, from slight climate change, turn into very large economic costs as this continues. For several centuries, after the stabilisation of green house gases (GHGs), global mean surface temperature and sea level will continue to rise [IPCC 2001a]. The expected consequences suggest substantial and widespread negative impacts by the time a 2ºC increase in average global temperature is achieved. Those contending that human induced warming could be beneficial appear to be concerned with the period well before this temperature is reached while ignoring the temporal and spatial distribution of impacts and changing frequency of extreme events.[3]

Detailed impact estimation requires such factors as regional temperature patterns, alterations in precipitation, the frequency and severity of climatic events, changes in cloud cover and wind speeds, atmospheric pollutant formation and deposition, and so on. If this kind of information were available then impact prediction might proceed to relate these parameters to specific ecosystems, their development and physical alterations in their structure and functioning. Ecosystem responses will impact human systems and so economists might then try to measure welfare impacts. Changes in human systems in turn feed back on the climatic and ecological systems.

An intricate chain of cause-effect relationships would need to be substantiated and analysed in order to predict the impacts of global climate change on human welfare in any detail. Due to the scale and complexity of the problem, the deterministic, exact and idealised methodology of cause-effect impact assessment is far from being either achievable or indeed relevant. There is then a division between taking impact estimates as objective facts which can be employed by economists to determine optimal pollution control, and seeing estimates as future scenarios which enable identification of systems resilience, vulnerable populations and potentially catastrophic events.

The former approach has been used to produce global cost and benefit estimates with the most recent example being a widely publicised UK government report [Stern 2006]. Economic analyses have often focused upon the US and then extrapolated the results globally, and so produce considerable distortions in predicting expected economic losses [Spash 2002b, 2007]. The IPCC concentrated upon impact assessment at the global scale until the late 1990s when a more regional scenario based approach was introduced [Watson et al 1997] and employed in the Third AR of Working Group II (2001). This approach tries to offer broad predictions across large regions with common climatic and geographic features, e g, arid western Asia, temperate Asia, tropical Asia.

Clearly, complex environmental problems, such as the enhanced greenhouse effect, which extend over long periods of time, are shrouded in uncertainty and challenge the idea of an objective consequential approach to impact assessment. This leaves us with a rough sketch of many possible events rather than a detailed picture of the type and timing of exact impacts. The problem for developing a socio-economic understanding lies in how such uncertainty, endemic to economics and policy, is addressed.

Weak and Strong Uncertainty

Public debate often interprets risk and uncertainty as identical, meaning unknowable outcomes. However, economists and scientists tend to restrict attention to uncertainty specified as the probability of known future events. This weak version of uncertainty can be contrasted with strong uncertainty where knowledge is actually lacking due to partial ignorance so that outcomes are unknown, and because outcomes are indeterminate and therefore unpredictable [Spash 2002b, chapters 4 and 5].

Climate Change as a Knowable Risk

The dominant weak uncertainty approach uses a probability density function to define concepts of normal, say, temperature on the basis of observation. Currently, actual global mean temperature has been estimated to have increased by 0.6°C from pre-industrial times. Confirming such a change is complicated by such things as overlap with the original probability density function, choice of reference period and measurement errors. Greater confidence then requires more observations. A focus on shifting means has tended to ignore the fact that temperature, precipitation, sea level and other variables will become more erratic, e g, concern about storm surges. The probability approach can also show the importance of critical ranges, e g, for the survival of species and ecosystem functioning. Knowledge of the changing vulnerability of species, the transition between climate states and combined mean and frequency alterations are all examples of the complications involved in assessing the impacts of climate change where numerous variables change simultaneously. The probability approach requires extreme simplification of uncertainty. Thus unknown futures are converted to risk and quantification is emphasised [IPCC 2001a: 17]. Uncertainty is believed to be reducible by research that allows the use of decision analytic frameworks and monetary valuation [IPCC 2001b: 17; IPCC 2001c: 11-13].

Recognising Strong Uncertainty

The idea that uncertainty can be reduced and even eradicated by more research is a fundamental epistemological error. Standard concerns over the impact of information on prediction can be related to two areas: (i) the ability to measure variables with minimal error; and (ii) imperfect knowledge about systems and how they change over time. The first area is concerned largely with estimable risk within empirically based scientific methodology, while the second moves firmly into the area of strong uncertainty where such a methodology is no longer valid. Problems arise in the application of standard risk assessment and probability theory because of the complexity of climate change, its possible consequences and their characteristics. For example, many potential climate change impacts are unique catastrophic occurrences (e g, disruption of ocean circulation, melting of West Antarctic ice sheet) and not the repeatedly observable physically inconsequential events of scientific experimentation and weak uncertainty.[4]

Keynes (1988), amongst others, argued that the terms risk (weak uncertainty) and (strong) uncertainty should be regarded as strictly separate.[5] Empirically observable and repeatable events, such as a coin toss, allow the construction of what are termed "objective" probabilities of an event occurring. However, as Loasby (1976: 8) states "the notion of an objective probability distribution carries a strong (but unstated) implication about the nature of the world, namely that it generates all the necessary (and quite unambiguous) frequency distributions from a stable population of events". Strong uncertainty then refers to the admission of a lack of knowledge about potential outcomes.

Such strong uncertainties often relate to events which have been excluded by assumption. Indeed, partial ignorance is an inevitable part of modelling where simplification enables understanding. For example, enhancing the greenhouse effect is the initiation of a complex process of change within a dynamic system. In practice scientific and economic approaches concentrate upon stationary states. Impacts are commonly based upon simulations using climatologists' general circulation models (GCMs) of the atmosphere, which have typically compared an assumed status quo with an equilibrium under an equivalent doubling of CO_2 [Watson et al 1997: 2]. The nature of the change between states is unknown, and in fact excluded by such GCM approaches and similar economic applications. There may be a smooth transition, a sudden shift or a "surprise".

The inability of science to provide experimentally derived theories to explain and predict the enhanced greenhouse effect has lead to the development of mathematical models and computer simulations which are essentially untestable. More generally the normal scientific approach has become dominant over all other ways of knowing, e g, common sense experience, inherited skills of living. In recognising the need for a new methodology to deal with strong uncertainty, Funtowicz and Ravetz (1993) have put forward the concept of post-normal science based upon assumptions of unpredictability, incomplete control and a plurality of legitimate perspectives. They regard an extended peer review approach as particularly relevant where systems uncertainties or "decision stakes" are high and research goals are issue-driven.

Wynne (1992: 116-17) has provided a complementary analysis focusing on the social context. He argues that apparently technical applied science questions are actually subject to assumed indeterminacy; such questions seem "normal" only because the surrounding context is artificially assumed to be constant and effectively unimportant. Recognising the existence of ignorance and indeterminacy requires understanding their complex social character, and how society adopts different types of uncertainty along with new products and technologies. Fundamentally, there is a need for social discourse on scientific information. The exaggeration of the scope and power of scientific knowledge creates "…a vacuum in which should exist a vital social discourse about the conditions and boundaries of scientific knowledge in relation to moral and social knowledge" [Wynne 1992: 115].

Scientific and economic knowledge must be placed explicitly within its social, moral and cultural perspective. This requires recognising that research communities are secluded and create closure and internal validity around particular constructs. Broadening the social circle of discussion is essential when deploying such knowledge in society. This allows questioning of the methodology, epistemology (commitments and expectations), definitions of boundaries between nature and culture, and the boundaries between objective determinism and human responsibility. If the process of creating scientific knowledge denies this openness then the extent to which it "naturalises" and limits our moral, cultural and policy horizons will remain hidden [Wynne 1992: 127]. Next I turn to an assessment of how economics measures up to such requirements.

Cost and Benefit Analysis

Continuing efforts are aimed at global cost-benefit analysis (CBA) of the enhanced greenhouse effect. Amongst these attempts those of American economist Nordhaus have been most influential.[6] For example, Rowlands (1995: 138) refers to the earlier work by Nordhaus as a prescription to the US administration to avoid cooperative action which commanded significant respect in that country. His work has indeed supported the US position in international negotiations against emission reduction. Numerous problems have been noted with respect to Nordhaus' work [Ayres and Walters 1991; Daily et al 1991; Funtowicz and Ravetz 1994; Spash 2002b], but with little effect. The support for a specific political viewpoint which is belief based and value laden, not factual, seems to be more important than the validity of economic analysis. Indeed this section aims to show how the dominance of strong uncertainty means that all economic modelling in this area is based upon assumptions reflecting the values, political and social norms of the analyst.

From Nordhaus to Stern

In his summary volume Nordhaus (1994) presents an optimisation model that is purposefully designed to run on a personal computer; this is in stark contrast with the scientific approach employing Cray supercomputers to run GCMs. While GCMs are still criticised for being too abstract and simple, Nordhaus rejects complex models in favour of "transparency". On the surface this appeal seems reasonable because of the tendency for excessive detail in modelling leading to results that are extremely precise but precisely wrong. Unfortunately, the transparency is rhetorical and the reported outcomes conceal the manipulation of quantitative uncertainty and value-commitments [Funtowicz and Ravetz 1994: 203]. His approach requires "developing" the scientific information to obtain "highly simplified aggregate relationships" [Nordhaus 1994: 23]. The assumptions then appear arbitrary, subjective and excessively abstracted from reality both on the physical science and economic sides [see Spash 2002b for details].

The way in which uncertain future events are characterised is particularly revealing. The main treatment of uncertainty is sensitivity analysis but this seems to get no attention in the conclusions. Although, perhaps obvious the way in which revenues from a carbon tax are used (recycled) has significant impacts on welfare and GDP estimates. For example, introducing carbon taxes while reducing distortionary taxes (e g, on labour) can cause gains of consumer and producer surplus (changes in deadweight loss) and their size determines the welfare impact of revenue recycling. Nordhaus (1994: 120-121) found annual GDP gains of $ 137 thousand million (1989 dollars) when taking this into account and that the optimal emissions reduction rose from 8.8 to 32 per cent which was associated with taxation moving from $ 5.24 to $ 59.00 per tonne CO_2 equivalent.[7] These results were for a deadweight loss of $ 0.3 per dollar of revenue, although Nordhaus notes estimates for the US are $ 0.5 to $ 1.0 and so the welfare gains would be much higher.[8] Hence the entire outcome of the model is reversed from GDP losses to GDP gains by having carbon taxes replace existing taxes. For some reason these results failed to get any emphasis.

Another aspect of uncertainty is the discussion of the difficulty to calibrate catastrophic scenarios "...which might be equivalent to the damages from a major war, or from a half century of Communist rule" [Nordhaus 1994: 115]. Rather than unknown surprises, such "catastrophes" are treated as known threshold events, at which large losses of GNP occur. That is, the states are assumed to be known, can be avoided and while large are bounded. There is considerable optimism concerning the ability to assess the risk of future events and the belief is expressed that many of the uncertainties can be resolved by further study or, at least, by the passage of time [Nordhaus 1994: 169]. This is a classic example of strong uncertainty being ignored and weak uncertainty being superimposed.

Overall this type of approach seems to present political argument as the outcome of an objective scientific modelling process. There are clearly a set of implicit values behind the work. For example, the idea of preserving nature at the expense of economic growth is termed "ultraconservative". Nature is described as exogenous and to be regarded as threatening with the potential to "deal us a nasty hand". The emphasis is upon a specific model of political economy which is, however, never explicitly described.

The more recent report by Stern (2006) cites Nordhaus extensively. This report has gained considerable publicity using an economic model which

> ... estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5 per cent of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20 per cent of GDP or more. In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1 per cent of global GDP each year [Stern 2006: vi].

There is nothing particularly new here. Some 14 years previously Cline (1992) produced a global CBA which gave a central estimate of damages reaching 6 per cent of GDP with a 10ºC warming, and under a pessimistic scenario, losses rose to 20 per cent of GDP. He also showed that, even with a 5 per cent discount rate, incorporating only a small probability of catastrophe within such economic models is all that is required to justify "aggressive" action today [Cline 1992: 6]. Despite claiming they are in the spirit of Nordhaus, the Stern report has conclusions closer to Cline who Nordhaus has strongly attacked in the past (the debate is documented in Spash 2002b). Strangely Stern's report totally ignores Cline.

However, the basic issue is not the detail but the whole approach. The work of Stern, like that of Cline, tries to balance a range of environmental concern, ethical issues and strong uncertainty within a standard neoclassical economic tradition. The result is clearly seen in the internal contradictions when trying to address the breadth of the subject area while summarising the whole issue within the narrow confines of X per cent growth gain at Y per cent growth cost. Let us consider what is required in order to get to such numbers: (i) the problem needs to be bounded both physically and institutionally; (ii) a set of cause and effect relationships must be constructed in order to link action to control pollutants with reduced damages; (iii) physical impacts must be characterised, described and measured; (iv) impacts must be associated with monetary values; (v) these "values" must be aggregated across space and time. We might want to add recommended project appraisal requirements, which are normally ignored, such as weighting (e g, by income) and sensitivity analysis. This process is difficult enough to undertake properly and with integrity for a small scale local project. Every stage outlined above is so highly contentious for a global CBA that the whole approach is, quite rightly, open to derision. That is even before any validity concerns are raised about the failure to respect microeconomic welfare theory upon which CBA is justified (e g, partial equilibrium analysis, ceteris paribus, marginal analysis, conditions for constant utility of money), let alone the meaning of monetary values, lack of pluralism, incommensurability, and so on.

At one point Stern (2006: 285) seems to reject aggregation of "mounting risk of serious harm to economies" stating that he sees no necessity "to add these up formally into a single monetary aggregate to come to a judgment that human induced climate change could ultimately be extremely costly". However, the report goes on to employ a model which involves "considerable simplification" to achieve "quantitative implications" in a utilitarian framework where costs and benefits are measured as percentages of economic growth. Some of the previous studies of the 1990s using similar modelling approaches conducted by Nordhaus, Tol and Manne are criticised:

> Above all, they carry out cost-benefit analysis appropriate for the appraisal of small projects, but we have argued in Chapter 2 that this method is not suitable for the appraisal of global climate change policy, because of the very large uncertainties faced. As a result, these studies underestimate the risks associated with large amounts of warming. Neither does any of these studies place much weight on benefits and costs accruing to future generations, as a consequence of their ethical choices about how to discount future consumption [Stern 2006: 298].

However, the fundamental methodology of the Stern report is the same, and this is even noted with the approach of Nordhaus and Boyer being cited as "perhaps the closest in spirit" [Stern 2006: 304]. Indeed the model used is stated to share "many of the limitations of other formal models". "Specifically, it yields a probability distribution of future income under climate change, where climate-driven damage and the cost of adapting to climate change are subtracted from a baseline GDP growth projection" [Stern 2006: 153].

Stern also follows Nordhaus in the treatment of uncertainty. The idea of uncertainty being different from risk is raised [Stern 2006: 33-34]. However, despite references to further exploration of the concept in Chapters 13 and 14 [Stern 2006: 27], there is nothing substantive anywhere on the subject. The treatment of strong versus weak uncertainty is particularly poor with a superficial reference to Keynes and to Knight. This is despite repeatedly telling us that there is considerable uncertainty over cause-effect relationships, that these will be outside empirical observation [Stern 2006: 293 ftnt 7], that the model used relies upon "non-existent data" [Stern 2006: 153], and that ethics and social values are crucial to the decision.

Cost Effectiveness Is No Better

Cost-effectiveness takes a given policy and assesses its associated costs, e g, the costs associated with achieving 60 per cent reduction in CO_2 emissions. This is meant to be less controversial because costs of pollution reduction are supposed to be easily observable in the market place unlike the benefits of avoiding damages. Despite this common misconception, cost-effectiveness does not avoid the problems outlined above. Emissions control costs are highly dependent upon such vagaries as energy forecasting and instrument design (e g, specification of tax, revenue recycling). Categories of cost and benefit can interchange; for example, the costs of carbon sequestration using reforestation must deduct the benefits of biodiversity, recreation, watershed stabilisation and so on which might be associated with the new forest.

Categories of costs and benefits are defined by the policy position, i e, what is the action under consideration. In the market place one person's cost is another person's benefit; you pay for a product and the supplier accepts your payment as fair exchange. The basic rule is to choose the status quo, or in the market the property rights, and define costs and benefits accordingly. More generally, an emphasis on the costs associated with any action is far from neutral and will convey specific moral and social connotations under different circumstances.[9]

The critiques and scepticism concerning benefit estimation are generally absent from cost-effectiveness analysis but without good cause, and even the meaning given to control "costs" can prove fallible. The fact that a "cost" seems to convey greater credibility and appears as a factual statement has affected the use of terminology, where damage costs is preferred to benefit estimation. There is also a moral perspective here because avoiding damages as a benefit of control is fundamentally different from incurring a "damage cost" in order to benefit from greater material throughput. The latter phrasing is used to pass the moral burden on to future generations (and other countries) who are assumed to benefit from GDP growth and must accept damages as another production cost.

Political Economy

CBA has been a popular tool for use within government bureaucracies because of the power wielded by business. Thus, financial information flows (with the externalities factored in) can remain dominant without regard to the assumptions upon which that information is based or the partial ignorance within which it is constructed, e g, mainstream economics addresses resource efficiency and positively excludes a range of other policy goals such as equity, fairness, justice and moral rights. Yet, these other considerations are impossible to exclude from the analysis.

Convergence between different studies has been taken as scientific validity, but this ignores the fact that there are widely different assumptions about which economic sectors are susceptible to climate change. For example, estimates of impacts on China show agriculture is a major loser according to Fankhauser (1995) and a major winner according to Nordhaus (1998). Human health and loss of life are the overwhelming monetary impact for Tol (1995), while for Nordhaus (1998) the largest loss category is the willingness to pay for avoiding the risk of an unspecific major GDP loss, which is a rather ad hoc and vague calculation. Clearly there is a large divergence in opinion as to the nature of impacts and their relative sizes, and much detail and information is lost by aggregation and the presentation of net GDP figures.

The basic approach assumes all categories are commensurable.[10] This is used by Nordhaus (1998) to introduce the category of recreational gains as a major offset to other losses. Hence the losses to agriculture in Europe are almost matched by recreational gains, and in China are three times the size of mortality and morbidity. In other words even with three times the amount of death and illness due to climate change the world is compensated because there are more opportunities for recreation and playing sports. The result for the US is that Nordhaus (1998) reduces damages by 38 per cent due to recreational gains. Accordingly Nordhaus (1998) seems to believe the enhanced greenhouse effect is only a real problem for the likes of India and Africa whose recreational opportunities are expected to worsen.

This picture seems to fit closely with the US political stance on emissions control, and who should pay. The message is that other countries, besides the US, especially the industrially developing countries, had better get involved because as the main polluter the US has little incentive to act. Unfortunately this neglects the rising damages and distributional consequences faced within the US. The "wait and see" approach then means irreversible commitment to further damages which become greater the longer the delay. Any extra recreational opportunities seem likely to prove inadequate and ethically questionable compensation for loss of life, flooding, ecosystems damage and crop failure. That those who gain and those who lose are different is concealed by aggregation, but when the impacts strike will be highly politically relevant.

The estimates of the benefits from emissions reductions would be greater if distributional weights were included in calculations in order to reflect damage suffered by low GHG emitters and Ekins (1995: 300) has argued in favour of such weightings. He notes that because high GHG emitters are also likely to be richer they will have a higher willingness to pay and so the damages they suffer actually gain greater weight in a CBA calculus. The poor low GHG emitters should be weighted more highly and he believes this would also help correct an unfair intergenerational distribution due to suffering damages without having been responsible for their cause. Of course once such weighting arguments are introduced an ethical debate is also raised more explicitly.

Value and Ethics

There is a clear desire to produce calculations which can be regarded as "rigorous", "scientific" and "objective" while still maintaining relevance to a subject which is complex, uncertain, politically charged and raises numerous moral questions. Economists have attempted to cloak themselves in a veil of innocence by claiming to merely be efficiency analysts who make no value judgments or moral choices but merely report societal preferences reflected in the market place. The fallacy of such a position is clear in the climate change debates concerning the discount rate, which impacts the moral treatment of future generations, and the valuation of human lives lost, which downplays death amongst the less wealthy, both covered in Spash (2002b). Any positive discount rate asymptotically reduces future impacts to zero and typical consumption growth rates do so within decades. Valuing loss of life in monetary terms has the result that the poor can be bought cheaply as they have a low income, so death in the developing economies of the south is less important than in the rich north.

Economics as a Moral Science?

There is a tension between two fundamentally different approaches to economics. When addressing discounting in the IPCC Second AR, the argument is stated to be a "conflict" between a descriptive approach from mainstream economics and the prescriptive approach of authors such as Cline. The case of the defenders of the mainstream neoclassical position is that:

> The alternative – overriding market prices on ethical grounds – opens the door to irreconcilable inconsistencies. If ethical arguments, rather than the revealed preferences of citizens, form the rationale for a low discount rate cannot ethical arguments be applied to other questions? [Arrow et al 1996].

Ethical questions fail to disappear just because a market price and economic analyst are substituted for ethical debate and public discourse. The contradiction is that economists, in applying preference utilitarianism, take a very specific philosophical and ethical position and then, as above, try to deny the relevance of ethics in economics. Moral dilemmas remain despite the attempts to remove their explicit discussion from the economic debate.

Many economists claim economic values and scientific research are separable from the moral and ethical dimensions of the problems they study. However, whether discounting or valuing damages, ethical and distributional issues are central to discussing the enhanced greenhouse effect. That there are contested social values and multiple perspectives on these issues means the boundaries drawn around research agendas are central points of debate and concern.

Technical economic analysis is used to present value judgments as apparently precise, and rigorous scientific numbers specified to three decimal places. As Funtowicz and Ravetz (1994: 201) note:

> By the time that the author has admitted the manifold oversimplifications and uncertainties in his analysis, and has shown how strong are the ad hoc adjustments and hunches which are needed to bring his numbers back into the realm of plausibility, we might ask whether the statistical exercises are totally redundant except for rhetorical purposes.

The idea that economists (or scientists) cannot, do not or should not make moral judgments in these cases is clearly false. The fact that they do so implicitly and these moral judgments may be regarded as objectionable when exposed, explains much of the aggression and emotion in the debate over valuation, e g, the income differentiated value of life. The pretence persists that ethical issues can be meaningfully separated from economic analysis of the enhanced greenhouse effect, and that such analysis can then be performed in seclusion.

A strange aspect of this issue is that economists may note the problem but go ahead with their narrow utilitarian calculations in any case. Thus the Stern report states: "it is not possible to provide a coherent and serious account of the economics of climate change without close attention to the ethics underlying economic policy raised by the challenges of climate change" [Stern 2006: 38]. Unfortunately the ethical discussion is extremely weak referencing one or two colleagues, who are noted in footnotes as having helped summarise things. The references are at best superficial and there are at least 50 relevant works relating to climate change missing [see review by Spash 2002a]. The uninitiated might think no one was discussing anything for the last half century that has to do with environmental values and ethics, let alone intergenerational equity and the enhanced greenhouse effect. Ethics is apparently served by discount rates based upon consumption growth.

Despite the absence of close attention to the ethics underlying economic policy on climate change, the Stern report feels able to dismiss "the right to be protected from environmental damage inflicted by the consumption and production patterns of others" on the basis that the proposition is unlikely to gain approval [Stern 2006: 42]. Instead the proposal is that "...future generations should have a right to a standard of living no lower than the current one" [Stern 2006: 42]. There is then no concept here, as in law, of the infliction of harm on the innocent as being something which incurs a liability. Simultaneously the transfer of basic wealth maintenance is conflated with the need for such compensation. As I have pointed out elsewhere any transfers to maintain welfare cannot be merged with compensation for harm of the innocent [Spash 1994, 2002b]. Food aid to less developed economies cannot justify polluting them with industrial and consumer waste.

Reflections Upon the Implications

Currently the worst offender by far in terms of human-induced climate change is the US on the basis of both absolute and per capita CO_2 emissions (see the table). High per capita emissions in developed economies can be associated with extremely poor energy efficiency (e g, low quality housing stock, lack of regulation, preference for consumption over investment), little or no public sector transport system, strong fossil fuel lobby groups and negligible alternative energy sectors. Australia is a prime example coming second only to the US in terms of per capita emissions. As a moral issue, recognition of the high per capita rate means individuals need to take more responsibility for their own actions. Of course, without government support the institutional barriers can be considerable, e g, sourcing materials, finding alternative energy providers, changing travel modes.

Direct regulation is criticised by economists as ineffective because humans are regarded as acting primarily out of self-interest and therefore deemed to require financial incentives to change their behaviour (i e, taxes or subsidies). The need for government intervention to adjust prices sits uncomfortably with the thrust of mainstream economics which favours a laissez-faire approach. Ironically, the mechanisms of the market are meant to correct the failures of the market. These ideas seem to have moved to centre stage in negotiations on climate change regulation where the US has held sway and the idea of trading emissions is becoming enshrined under the Kyoto Protocol of the Framework Convention on Climate Change. Trading alone does nothing to control climate change and merely redistributes wealth. It is the cap or quota that establishes the available number of permits which achieves GHG emissions reduction. Indeed we may worry that creating a multi-billion dollar trade market provides an incentive to maintain the market rather than phase it out over time in order to remove what is being traded, i e, carbon.

For countries such as India and China the picture is mixed because they have high and rapidly growing absolute emissions but relatively low per capita ones. This led Agarwal and Narain (1991) to suggest per capita carbon quotas be set at a level which would achieve climatic stability. As cuts of at least 60 per cent in carbon equivalent emission are required, the burden would fall heavily on those countries with the highest per capita emission, namely, US, Australia, Canada, Saudi Arabia, western Europe, Russia, Poland, Ukraine, Korea, Japan and South Africa. With discussion of per capita levels of around 0.5 metric tonnes, the likes of India could actually increase emissions under such an approach. Indeed this argument can be taken a step further. Parikh (1995) has argued that the high per capita carbon emitters are in fact in debt to those in the world with low carbon emissions,

Table: Top 20 Carbon Dioxide Emitting Countries

	Total CO_2 (Metric Tonne 000s)	World Proportion (Percentage)	Per Capita (Metric Tonne)	Per Capita (Rank)
US	1486801	23.8	5.43	1
China (mainland)	848266	13.6	0.68	18
Russian Federation	391535	6.3	2.66	6
Japan	309353	5.0	2.45	9
India	289587	4.6	0.29	20
Germany	225208	3.6	2.75	5
United Kingdom	148011	2.4	2.51	8
Canada	127517	2.0	4.17	3
Italy	113238	1.8	1.97	12
Mexico	102072	1.6	1.07	17
France	100951	1.6	1.72	14
Republic of Korea	99260	1.6	2.64	7
Ukraine	96510	1.5	1.9	13
South Africa	93808	1.5	2.38	10
Australia	90470	1.4	4.88	2
Poland	87807	1.4	2.27	11
Brazil	81758	1.3	0.49	19
Iran	79119	1.3	1.2	16
Saudi Arabia	77237	1.2	3.83	4
Spain	67468	1.1	1.7	15
All 20	4915976	78.7	2.35	
World	6243592	100	1.13	

Source: Marland et al 2001.

because they are exploiting a share of a common carbon sink which does not belong to them. If industrialised economies were to pay for their excessive use, Parikh estimates the rich north owes the poor south $ 75 thousand million. This and similar calculations of the carbon debt are discussed by Martinez-Alier (2002: chapter 10) who broadens the concept to other cases and terms the issue "ecological debt".

Countries like India also have considerable income inequality and an emphasis has been placed upon traditional economic growth as a means to relieving poverty. The concern that economic growth will be capped by emission controls is put forward as a reason for avoiding regulation. Here the US has provided a bad example, having failed to regulate its own emissions on the grounds of protecting its own business enterprises. Events like Hurricane Katrina show that the US is just as susceptible to the climate as everyone else. The US also provides evidence for the fallacy that traditional growth alone either removes income inequality or continuously improves human well-being. Americans are reported to "...have remained much as Alexis de Tocqueville found them in the 19th century: 'So many lucky men, restless in the midst of abundance'" [*Economist* 2006]. Yet the myth of growth continues and developed economies are failing to implement alternative economic models. They need to lead by example and if they fail to do so, and less developed economies follow in their footsteps, then environmental catastrophes will follow.

The impact of policy responses to climate change on world trade (e g, carbon taxes) is also worth reflecting upon. Strangely, some work in this area labels environmental policy as a potential source of trade tensions [Whalley 1991]; neglecting the fact that such policy is in fact aimed at removing the impact upon trade relations previously created by countries exporting pollution. This distorted perspective arises because the polluted environment is assumed to be the status quo and the costs of policy intervention are considered while ignoring the benefits. Adams and Crocker (1991: 310) have shown that improving air quality in the US has international trade implications which actually benefit non-US citizens by increasing their consumers' surplus. Thus, in order to recognise the full trade impact of global climate change, economic analysts must avoid concentrating upon the potential for carbon taxes to fall heavily on industrially developed countries and go beyond the comparative safety of analysing pollution control costs using pre-existing economic models. This requires discussing the potential benefits from avoiding damages to foreign traders due to perturbation of global environmental systems. Yet there is no incentive to do so when countries like India fail to engage in the international debate.

Value Loaded Knowledge

The type of work being produced by economists exemplifies how implicit value loaded boundaries are drawn in terms of designating which knowledge is employed. While the social aspect of economic knowledge may be deemed to make it implicitly subjective, a similar methodological problem also faces natural scientists. That is, how environmental problems are characterised is seen to be determined by assumptions which restrict the focus of any given research. Some of the problems facing economic evaluation of the enhanced greenhouse effect are: (i) multiple baseline scenarios making cost assessments non-comparable; (ii) large-scale, long-term changes meaning welfare theory assumptions simply fail to hold so there is no basis for comparison of winners and losers; (iii) control measures being conflated with actions under business as usual; (iv) use of GNP figures bounded by historical estimates ignoring the impact of climate change on relative prices; (v) numerous ad hoc assumptions to cover partial ignorance; (vi) value transfer out of time and place; and (vii) excessive aggregation.

The problems outlined here show how economic assessment fails to provide an answer as to what should be done. The costs of reducing CO_2 emissions may be quite high or there may be net gains depending upon the options chosen by the analyst. Once the whole global economic and environmental system is up for grabs, off into the distant future, there is no correct prediction of outcomes. The benefits of reducing emissions are beyond economists' ability to estimate, so the extent to which control options should be adopted, on efficiency grounds alone, is unknown. Political and social debate is unavoidable and necessary, disputes over values are normal, and ethics inseparable from economic analysis.

Economic assessments of the enhanced greenhouse effect fail to address environmental and social complexity. Specific problems are the treatment of uncertainty in the estimation of benefits and cost, the value of morbidity and mortality, the distribution of costs and benefits, the moral standing of future generations and the very size of the problem (there is a point at which marginal welfare analysis loses its theoretical basis). There are many areas of uncertainty, for example, concerning regional impacts of climate change, how people and natural systems will adapt, and the character of the world's economies in the distant future. There are the standard problems of valuing non-market effects such as the displacement of wildlife, the human misery of environmental refugees and loss of life. These are areas which pose moral and political questions.

Another challenge, which has received little attention, is how to treat long-term damages incurred by future generations who will suffer damages but may themselves contribute little in terms of GHG emissions. Implicitly the regard given to future generations plays an important role in the value placed upon climate change projections, because future generations are expected to suffer the worst consequences and delaying action is largely justified by this intergenerational "externality". Current models tend to perpetuate the myth that the consequences of our actions will be felt by those on the other side of the world and living in the distant future and then encourage discounting any concerns.

The way in which the regional impacts are expected to, and actually do, materialise influences international negotiations on the control of GHGs, and the timing, nature and extent of those controls. Unfortunately the impacts between and within nation states will be uneven and are likely to fall most heavily on those least able to adapt, i e, the resource poor. Economics is notoriously bad at dealing with distributional issues because these tend to be regarded as political choices separable from resource efficiency. The optimal level of emissions reduction is discussed without considering who bears the costs and who gains the benefits. Yet these would seem to be crucial aspects of controlling GHG emissions. When those emitting pollution suffer the associated pollution damages, without affecting others, they may be regarded as in need of help, but when polluters knowingly inflict damages on others, without affecting themselves, they are best regarded as in need of prosecution.

An economic system which rewards successfully externalising the harm created by individual actions can be viewed as having led to the dramatic potential damages faced by the world under the enhanced greenhouse effect. Deliberately harming the innocent would appear morally repugnant but not so when all values are commensurable so that extra recreation for Americans can justify the loss of life of Indians. Economic analysts depending upon modern welfare economics are in the uncomfortable position of justifying any actions if society or individuals can potentially (but not actually) transfer resources to those harmed, i e, the benefits could potentially compensate for the losses. The rising popularity of global climate change as a matter for economists to consider will either force these matters in to the debate, or show how strong the dominant approach to economic assessment remains by relegating them to the sidelines. EPW

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Notes

1 The most recent assessment was presented in January 2007.

2 Much attention has focused upon CO_2 which only contributes 55 per cent of climate forcing [Watson et al 1990: 7-8]. The concentration of all GHGs is important, including their different radiative properties and residence times.

3 Many events (such as thunderstorms, tornadoes, hail, and lightning) are excluded from climate models [IPCC 2001a: 15].

4 The supposed solution is the use of probabilities placed by a decision-maker or expert upon the likelihood of an event to obtain "subjective" probabilities. This achieves the move from "objective risk" to "subjective risk", but neither actually addresses strong uncertainty.

5 Keynes developed these ideas between 1906 and 1911, debating them widely from 1911 onwards and publishing in 1921. Some cite Knight (1921) as originating the division of risk and uncertainty, but Keynes predates this by a decade.

6 His faith in the potential of neoclassical modelling is witnessed by his stating that: "Our future lies not in the stars but in our models" [Nordhaus 1994: 6].

7 3.67 tonnes of CO_2 equals 1 tonne of carbon [Brown and Adger 1994: 217].

8 Deadweight loss is the reduction in consumer and producer welfare when a tax on a good is introduced, because less of the product is then demanded and supplied.

9 Framing in terms of costs can be culturally inappropriate and or morally repugnant. When giving gifts, a common social practice is to remove the price label rather than emphasise to the recipient how much the item cost. When seeing a person drowning the expected action of a potential rescuer in a nearby boat is to spontaneously go to his aid rather than sit down to consider the costs in terms of say the petrol used, his time and the inconvenience.

10 Commensurability is a highly contested assumption which is rejected in applied philosophy but persists in economics [O'Neill 1997; Aldred 2002; Aldred 2006].

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